Sugarcane

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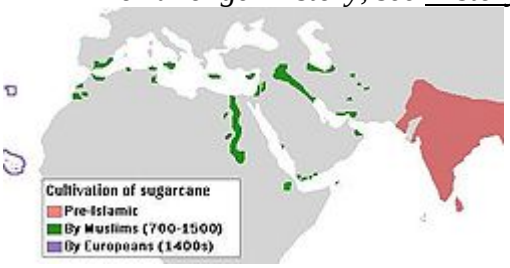
Sugarcane, is any of six to thirty-seven species (depending on taxonomic system) of tall perennial grasses of the genus *Saccharum* (family Poaceae, tribe Andropogoneae). Native to warm temperate to tropical regions of Asia, they have stout, jointed, fibrous stalks that are rich in sugar, and measure two to six meters (six to nineteen feet) tall. All sugar cane species interbreed, and the major commercial cultivars are complex hybrids. Brazil produces about one-third of the world's sugarcane.

Cultivation and uses

Sugar cane is grown in over 110 countries with an estimated total production of 1,591 million metric tons[1] in 2007, more than six times the output of sugar beet. In 2005, the world's largest producer of sugar cane was Brazil, followed by India.[2] Sugar cane products include table sugar, Falernum, molasses, rum, cachaça (the national spirit of Brazil), and ethanol. The bagasse that remains after sugar cane crushing may be burned to provide heat and electricity. It may also, because of its high cellulose content, serve as raw material for paper, cardboard, and eating utensils that, because they are by-products, may be branded as "environmentally friendly."

History of sugarcane

For a longer history, see History of sugar.



The diffusion of sugarcane in pre-Islamic times (shown in red), in the medieval Muslim world (green) and by Europeans (violet)[3]

Sugarcane is indigenous to tropical South Asia and Southeast Asia.[4] Different species likely originated in different locations with *S. barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea.[4] Crystallized sugar was reported 5,000 years ago in India.

Around the eighth century A.D., Arabs introduced sugar to the Mediterranean, Mesopotamia, Egypt, North Africa, and Spain. By the tenth century, sources state, there

was no village in Mesopotamia that did not grow sugar cane.[3] It was among the early crops brought to the Americas by the Portuguese.

Boiling houses in the 17th through 19th centuries converted sugarcane juice into raw sugar. These houses were attached to sugar plantations in the western colonies. Slaves often ran the boiling process, under very poor conditions. Made of cut stone, rectangular boxes of brick or stone served as furnaces with an opening at the bottom to stoke the fire and remove ashes. At the top of each furnace were up to seven copper kettles or boilers, each one smaller and hotter than the previous one. The cane juice began in the largest kettle. The juice was then heated and lime added to remove impurities. The juice was skimmed, then channeled to successively smaller kettles. The last kettle, which was called the 'teache', was where the cane juice became syrup. The next stop was a cooling trough, where the sugar crystals hardened around a sticky core of molasses. This raw sugar was then shoveled from the cooling trough into hogsheads (wooden barrels), and from there into the curing house.

A sugar plantation on the island of Réunion in the late 1800s

Sugarcane is still extensively grown in the Caribbean. Christopher Columbus first brought it during his second voyage to the Americas, initially to the island of Hispaniola (modern day Haiti and the Dominican Republic). In colonial times, sugar formed one side of the triangular trade of New World raw materials, European manufactures, and African slaves. France found its sugarcane islands so valuable, it effectively traded its portion of Canada, famously dubbed "a few acres of snow," to Britain for their return of Guadeloupe, Martinique and St. Lucia at the end of the Seven Years' War. The Dutch similarly kept Suriname, a sugar colony in South America, instead of seeking the return of the New Netherlands (New York). Cuban sugarcane produced sugar that received price supports from and a guaranteed market in the USSR; the dissolution of that country forced the closure of most of Cuba's sugar industry. Sugarcane remains an important part of the economy of Belize, Barbados, Haiti, along with the Dominican Republic, Guadeloupe, Jamaica, and other islands.

Sugarcane production greatly influenced many tropical Pacific islands, including Okinawa and, most particularly, Hawai‘i and Fiji. In these islands, sugarcane came to dominate the economic and political landscape after the arrival of powerful European and American agricultural businesses, which promoted immigration of workers from various Asian countries to tend and harvest the crop. Sugar was the dominant factor in diversifying the islands' ethnic makeup, profoundly affecting their politics and society.

Brazil is the biggest grower of sugarcane, which goes for sugar and ethanol for gasoline-ethanol blends (gasohol) for transportation fuel. In India, sugarcane is sold as jaggery, and also refined into sugar, primarily for consumption in tea and sweets, and for the production of alcoholic beverages.

Cultivation

Sugar cane field on Madeira

Sugarcane cultivation requires a tropical or temperate climate, with a minimum of 60 centimetres (24 in) of annual moisture. It is one of the most efficient photosynthesizers in the plant kingdom. It is a C-4 plant, able to convert up to 2 percent of incident solar energy into biomass.[*citation needed*] In prime growing regions, such as India, Peru, Brazil, Bolivia, Colombia, Australia, Ecuador, Cuba, the Philippines, El Salvador and Hawaii, sugarcane can produce 20 kilograms (44 lb) for each square meter exposed to the sun.[*citation needed*]

Although sugarcanes produce seeds, modern stem cutting has become the most common reproduction method. Each cutting must contain at least one bud and the cuttings are sometimes hand-planted. In more advanced countries like the United States and Australia, billet planting is common. Billets harvested from a mechanical harvester are planted by a machine which opens and recloses the ground. Once planted, a stand can be harvested several times; after each harvest, the cane sends up new stalks, called **ratoons.** Successive harvests give decreasing yields, eventually justifying replanting. Two to ten harvests may be possible between plantings.[*citation needed*]

Sugarcane is harvested by hand and mechanically. Hand harvesting accounts for more than half of production, and is dominant in the developing world. In hand harvesting the field is first set on fire. The fire burns dry leaves, and kills any lurking, venomous snakes, without harming the water-rich stalks and roots. Harvesters then cut the cane just above ground-level using cane knives or machetes. A skilled harvester can cut 500 kilograms (1,100 lb) of sugarcane per hour.[*citation needed*]

Photo of two trailer truck filled with plant cane

Mechanical harvesting uses a sugarcane combine (or chopper harvester), a harvesting machine originally developed in Australia. The Austoft 7000 series was the original modern harvester design that has now been copied by other companies including Cameco/ John Deere. The machine cuts the cane at the base of the stalk, strips the leaves and deposits the cane into a transporter, while blowing the thrash back onto the field. Such machines can harvest 100 long tons (100 t) each hour, but machine-harvested cane must rapidly arrive at the processing. Once cut, sugarcane begins to lose its sugar content, and damage to the cane during mechanical harvesting accelerates this decline.

Pests

The cane grub can substantially reduce crop yield by eating roots; it can be controlled with Confidor or Lorsban. Other important pests are the larvae of some butterfly/moth species, including the turnip moth, the sugarcane borer (*Diatraea saccharalis*), the Mexican rice borer (*Eoreuma loftini*); leaf-cutting ants, termites, spittlebugs (especially *Mahanarva fimbriolata* and *Deois flavopicta*), and the beetle *Migdolus fryanus* also are significant pests. The planthopper insect *Eumetopina flavipes* acts as a phytoplasma vector, which causes the sugarcane disease ramu stunt[5].But sugar cane grown in the land becomes un-fertile

Processing

Manually extracting juice from sugarcane

A truck hauls cane to a cane sugar mill in Florida, USA

Sugar crystals

The Santa Elisa sugarcane processing plant, one of the largest and oldest in Brazil, is located in Sertãozinho, Brazil

Evaporator with baffled pan and foam dipper for making ribbon cane syrup. Three Rivers Historical Society Museum at Browntown, South Carolina

Traditionally, sugarcane processing requires two stages. Mills extract raw sugar from freshly harvested cane, and sometimes bleach it to make "mill white" sugar for local consumption. Refineries, often located nearer to consumers in North America, Europe, and Japan, then produce refined white sugar, which is 99 percent sucrose. These two stages are slowly merging. Increasing affluence in the sugar-producing tropics increased demand for refined sugar products, driving a trend toward combined milling and refining.

Milling

Small rail networks are a common method of transporting cane to a mill. Refineries test newly arrived cane for Brix and trash percentage.

The mill washes, chops, and uses revolving knives to shred the cane. Shredded cane is repeatedly mixed with water and crushed between rollers; the collected juices (called garapa in Brazil) contain 10–15 percent sucrose, and the remaining fibrous solids, called bagasse, are burned for fuel. Bagasse makes a sugar mill more than energy self-sufficient; surplus bagasse goes in animal feed, in paper manufacture, or to generate electricity for sale. The cane juice is next mixed with lime to adjust its pH to 7. This mixing arrests sucrose's decay into glucose and fructose, and precipitates some impurities. The mixture then sits, allowing the lime and other suspended solids to settle. The clarified juice is concentrated in a multiple-effect evaporator to make a syrup about 60 percent sucrose by weight. This syrup is further concentrated under vacuum until it becomes supersaturated, and then seeded with crystalline sugar. On cooling, more sugar crystallizes from the syrup. A centrifuge separates the sugar from the molasses. Additional crystallizations extract more sugar; the final residue is called blackstrap.

Raw sugar is yellow to brown. Bubbling sulfur dioxide through the cane juice before evaporation bleaches many color-forming impurities into colorless ones. This *sulfitation* produces sugar known as "mill white", "plantation white", and "crystal sugar". Such sugar is the most commonly consumed in sugarcane-producing countries.

Refining

Sugar refining further purifies the raw sugar. It is first mixed with heavy syrup and then centrifuged in a process called 'affination'. Its purpose is to wash away the sugar crystals' outer coating, which is less pure than the crystal interior. The remaining sugar is then dissolved to make a syrup, about 70 percent solids by weight.

The sugar solution is clarified by the addition of phosphoric acid and calcium hydroxide, which combine to precipitate calcium phosphate. The calcium phosphate particles entrap some impurities and absorb others, and then float to the top of the tank, where they can be skimmed off. An alternative to this "phosphatation" technique is 'carbonatation,' which is similar, but uses carbon dioxide and calcium hydroxide to produce a calcium carbonate precipitate.

After filtering any remaining solids, the clarified syrup is decolorized by filtration through activated carbon. Bone char is traditionally used in this role.[6] Some remaining color-forming impurities adsorb to the carbon. The purified syrup is then concentrated to supersaturation and repeatedly crystallized in a vacuum, to produce white refined sugar.

As in a sugar mill, the sugar crystals are separated from the molasses by centrifuging. Additional sugar is recovered by blending the remaining syrup with the washings from affination and again crystallizing to produce brown sugar. When no more sugar can be economically recovered, the final molasses still contains 20–30 percent sucrose and 15–25 percent glucose and fructose.

To produce granulated sugar, in which individual grains do not clump, sugar must be dried, first by heating in a rotary dryer, and then by blowing cool air through it for several days.

Ribbon cane syrup

Ribbon cane is a subtropical type that was once widely grown in the southern United States, as far north as coastal North Carolina. The juice was extracted with horse or mule-powered crushers; the juice was boiled, like maple syrup, in a flat pan, and then used in the syrup form as a food sweetener. It is not currently a commercial crop, but a few growers find ready sales for their product[*citation needed*]. Most U.S. sugarcane production occurs in Florida and Louisiana, and to a lesser extent in Hawaii and Texas.